A DEM based breakage model for coarse aggregates

Mauricio Tapias*, Eduardo Alonso* and Josep Gili*

* Department of Geotechnical Engineering and Geosciences
Universitat Politècnica de Catalunya (UPC)
Campus Norte UPC, 08034 Barcelona, Spain
e-mail: mauricio.tapias@ upc.edu

ABSTRACT

Coarse granular aggregates are often found in civil and mining engineering works: rockfill dams and embankments, breakwaters, railway ballast and mine heaps. Their behaviour is significantly affected by particle breakage which, in turn, depends on grain strength and geometry, particle loads within the aggregate, and the prevailing relative humidity (RH). DEM models have been published to include particle breakage into the computational cycle. In most cases the breakage is explained by the failure of a bonding established among particles.

In the work developed a different approach, which is believed to be closer to actual breakage mechanisms, has been introduced. A particle is assumed to break when an existing defect or crack propagates and reaches the particle boundary. Crack propagation velocity depends on the rock toughness, the initial size of the crack, the mode of propagation and the RH. This phenomenon, at the particle scale, has been approximated, within the DEM model by two analytical solutions: the state of the stress inside a spherical particle and the propagation velocity of cracks, whose initial length is randomly selected. These closed form solutions help to reduce the computational cost.

Non-spherical particle shapes are built by aggregation of spheres. Resulting particle shapes after breakage, follow a protocol inspired in actual experimental observations.

The model is capable of reproducing main phenomena observed in rockfill behaviour including water effects, collapse strains and time-dependant behaviour. The model developed is first calibrated by means of laboratory tests, including a large diameter one-dimensional compression test and it is shown to predict independently performed triaxial tests on limestone gravels.